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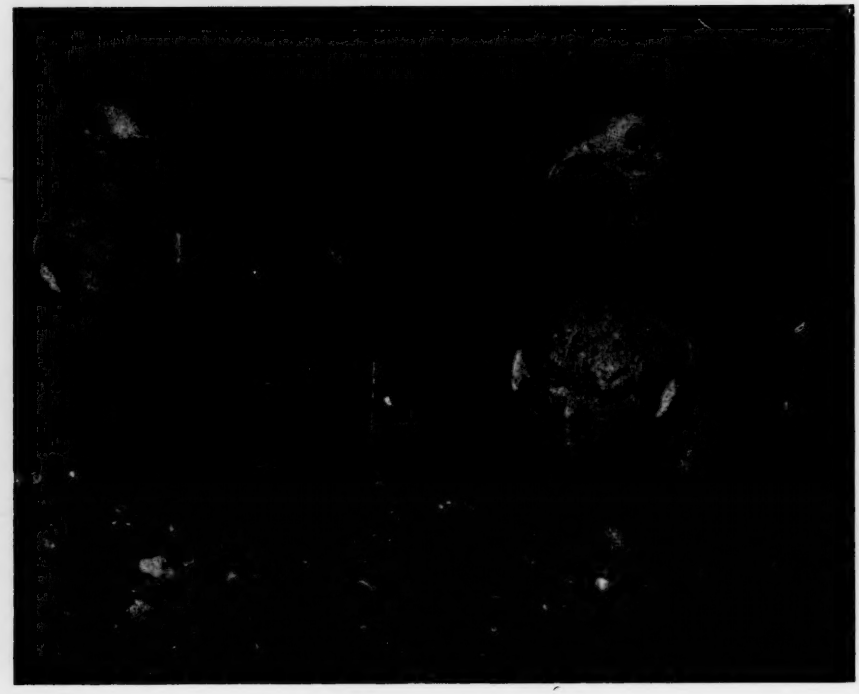

DOVECOTE GODIVAS
(SEE PAGE 4)

Spaghetti Chromosomes

Sex-Linked Muscle Atrophy

Ragged-Wing Fowls

Wry-Tailed Cattle

Triploid Ryegrass

VOLUME 35 JANUARY, 1944 NUMBER 1

The American Genetic Association

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The

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Vol. XXXV JANUARY, 1944 No. 1

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TO SOME it will be tasteless to others it may be bitter, sour, sweet, or salty. These differences in taste reaction are inherited, inability to taste the substance apparently being transmitted as a Mendelian character. [A. F. Blakeslee and A. E. Fox, *Journal of Heredity*, March 1932 and *Proc Nat Acad Sci*, January 1932.]

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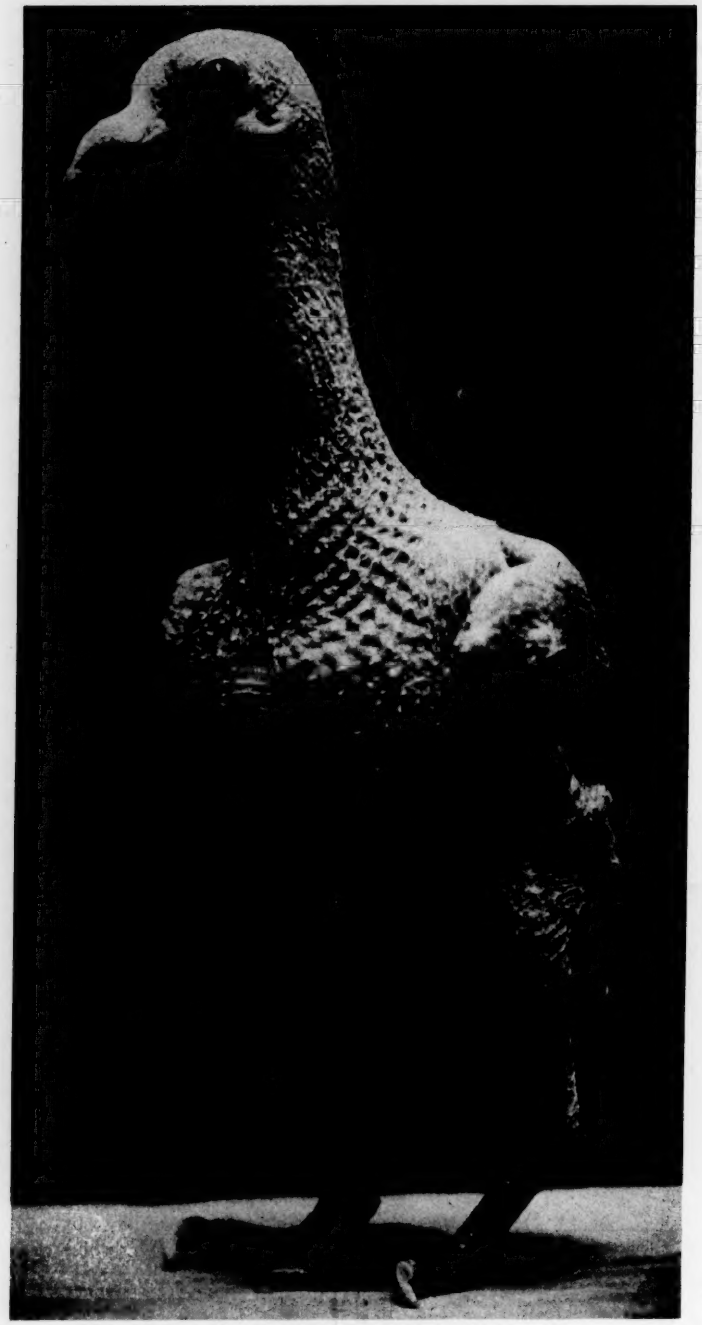


"GRANDPAPA ALOPECIA"

Figure 1

He was the last survivor of two pairs of featherless pigeons originally secured in 1938. Through the timely intervention of artificiai insemination, he became the father of four feathered offspring before his death in June, 1940. The four naked grandchildren shown in Figure 2 testify to the transmissibility of this trait by recessive Mendelian inheritance. The perpetuation of the strain is so tedious that it will be a long time before the housewife can buy her squabs gene-plucked.

NAKED PIGEONS*

LEON J. COLE AND RAY D. OWEN
University of Wisconsin

PIGEON courtship, with its strutting, cooing and puffing out of feathers is an interesting performance. When there are no feathers to puff or to clothe the performer, it becomes a ludicrously macabre travesty of a dance by the proverbial "picked chicken."

Two pairs of featherless pigeons, the progeny of a single pair of normally feathered Homers, were secured in 1938 from Mrs. S. K. Haywood of Spokane, Washington. They were the only survivors of a small flock originally obtained from Mrs. M. A. Summers of the same city, who had reported in the popular press the occurrence of naked pigeons in her flock as early as 1931. It was thought these naked birds were all from eggs of one female, but the parentage was uncertain.

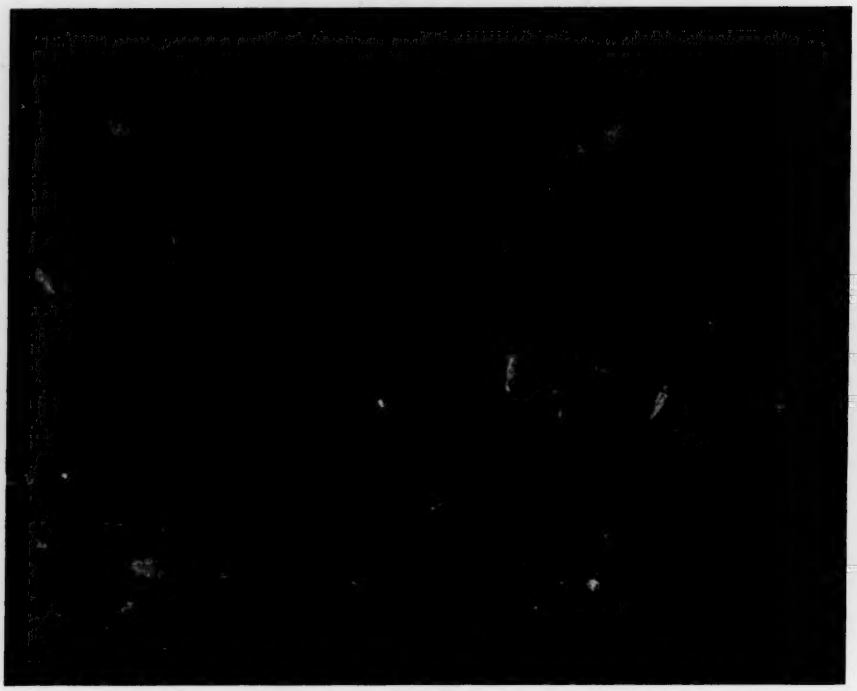
Several unsuccessful attempts were made to obtain progeny from the naked birds by natural matings to normal pigeons. One female died less than a month after she arrived in Madison; the other lived about a year, and was paired to two different normal males. The birds seemed to be mated normally but none of the ten eggs the female laid was fertile. One of the males was stolen from his cage about 15 months after he was received. He had been mated with a normal female, but none of the 35 eggs laid by her was fertile. The remaining male (Figure 1) was mated to three different females. These three matings produced 8, 32, and 21 eggs respectively, but again there was no fertility. It is readily understandable that naked males mated to normal females should not give fertility, since balancing with the wings is an important factor in successful copulation. Why the reciprocal mating should not be successful is not so evident.

The spring of 1940 found us with only a single male, of the four naked birds originally purchased, and no progress made towards perpetuation of the trait. At that time, however, a technique of artificially inseminating small birds was developed,[3] and although the featherless bird was not a particularly good producer of semen, four progeny were obtained from him by this method before his death in June, 1940. The cooperating female was a blue bar. The progeny became fully feathered and were entirely normal in appearance. Three of them (two males and one female) were blue checks, and the other (a male) a red check. It was therefore apparent that the naked sire was genetically a heterozygous red check; had he been feathered he would have been that color.

The female F_1 (E479E) was mated with one of her brothers (E479A) to produce family E558, summarized in Table I. Fertility was high in this mating, only two of the 32 eggs of record failing to show at least some embryonic development. On the other hand, hatchability was poor, as 13 of the 30 embryos died before hatching. Of the 17 that hatched, two died before feathering, but the abundant down indicated that they would have feathered normally. The reappearance of naked in this conventional F_2 progeny, in the ratio of four naked (Figure 2) to 13 normal, seems to be clear indication that naked is inherited as a simple recessive. That it is not sex-linked was shown by the fact that the F_1 female was normal. We therefore propose for the autosomal gene for *naked* in pigeons the symbol *na*.

The sex-ratio in this mating, as determined for 16 birds, was 10 males to six females. This does not diverge significantly from equality. All four of the naked birds produced in this mating were males, which may be attributable

*Paper No. 323 from the Department of Genetics, Wisconsin Agricultural Experiment Station.



HARDLY A QUILL IN A CARLOAD
Figure 2

Four grandchildren of the original naked male (Figure 1) who appeared as segregates from interbreeding the normal-appearing feathered offspring of the naked × normal mating. These definitely underdressed pigeons resented sweaters which were knitted for them, and had to make up their heat-deficiency by being kept in an extra warm room.

to chance alone, though it is possible there is a greater mortality among female embryos. There has been a conspicuously higher death rate among the adult females and this has made it extremely difficult to keep the naked character going by natural matings. Thus, in spite of our efforts, we at present have remaining only two F_1 males known to be heterozygous for *na* and no known heterozygous females with which to mate them. Testing the few females which have a two-out-of-three or an even chance of carrying the recessive gene is a space-, feed- and time-consuming process with pigeons. Breeding directly from the naked males by artificial insemination requires concentration of effort and time, and when they are poor producers of semen, as they have proved to be, results are uncertain at best. All in all, trying to perpetuate characters of this sort in pigeons is a headache!

Another son (E479B) of the original featherless male was mated to an unrelated normal pigeon. The 21 progeny of this mating (E582) were all normally feathered—further proof, were it necessary, of the recessive nature of nakedness.

Description

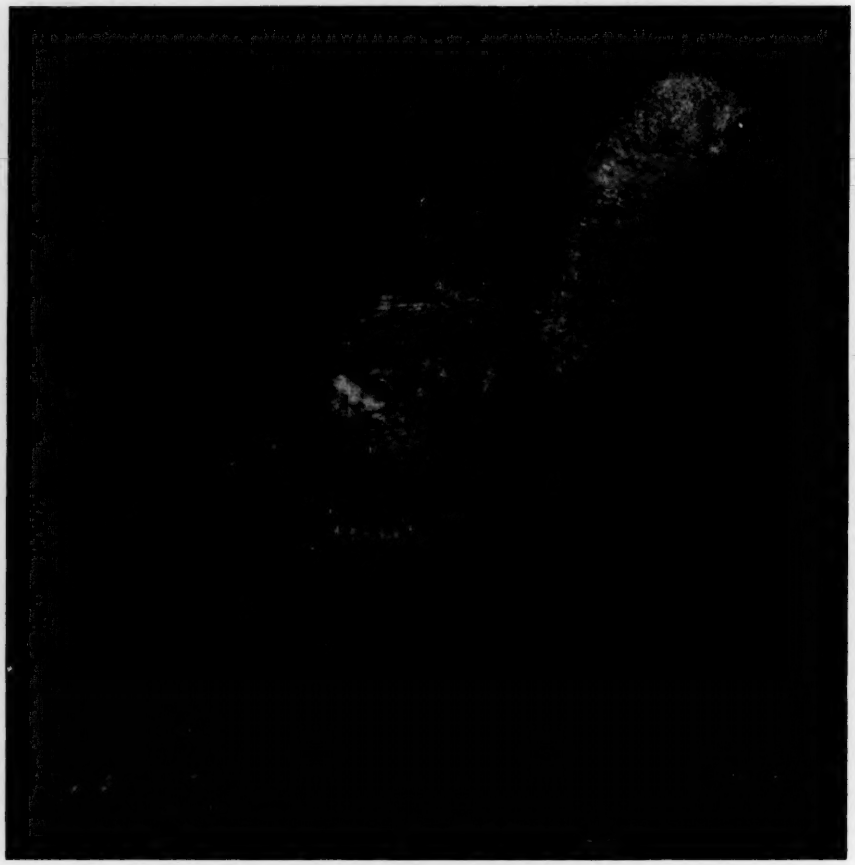
The nestling down of "naked" squabs is rather sparse and short, in sharp contrast to the abundant down of "normal" squabs. Nevertheless, the action of this factor on down growth is not extreme (as is the action of the dilution factor,

BEGINNINGS OF FEATHERS
Figure 3

The adult birds appear to be completely naked. This squab (No. E588A) is one of the birds shown in Figure 2. At 23 days of age it had abortive primaries which later became abraded. Perhaps it is the suggestion of such feathers which later disappear that encourages the naked birds to take "flight" unhesitatingly from a table in the hope of making a satisfactory landing. The "crash" which ensues does not deter them from later attempts.

for example). But in spite of the fairly adequate natal down, the "naked" bird is not equal to the task of growing normal feathers.

Adult naked pigeons are remarkably consistent in degree of feathering. As shown in the illustrations, they appear at first glance to be entirely featherless. Closer inspection, however, reveals that on most of the feather tracts the follicles have erupted short, pointed stubs. On the shoulders these stubs may reach a length of two millimeters. The primaries and primary coverts are represented by somewhat longer, frayed stubs, occasionally a centimeter long. (Figure 3.) These stubs, being fragile and quite brittle, are kept broken off and worn down by the activity of the birds. In younger birds the distal primaries may show indications of barb development, but in older birds only the frayed shafts remain. The tail feathers show no comparable development. Occasionally, as in the naked fowl, feather follicles on the wings fail to erupt but produce swellings, "as if



ANTICLIMAX IN IMPRESSING A MATE

Figure 4

Naked pigeon in the act of cooing and bowing. The neck is distended and flushed; it would later be brought down to a horizontal position, completing the bow. These featherless birds appear to have no apprehension that they are unclothed and solemnly perform activities that are merely absurd in the absence of feathers.

some constriction were preventing their contents from being pushed out."[2]

The tip of the wing is folded back, so that it is roughly parallel with the radius when the bird is at rest. Although their wings are almost useless organs, these birds seem unable to learn to regard them as such. Placed on a table, they will hopefully take off into space, beating their wings vigorously, as though confident of a controlled landing which, however, ends in a "crash." At other times they stand for minutes on tiptoe in their cages, flapping their wings in determined calisthenics. When two naked males are put together they are as prone to fight as normal pigeons and buffet each other with wing and beak. Although their skin is thick and tough, severe wounds will result if they are not separated. They are also active and aggressive lovers. Inadequate attire pro-

duces no inferiority complex in them; they strut and coo, puff and bow as if arrayed in the finest of raiment (Figure 4). In the latter exercise the head is lowered until the neck is approximately horizontal. At the same time the neck swells and the skin reddens, presumably with a suffusion of blood accompanying the action of the dermal muscles, which would elevate the feathers if there were any to be raised. The expansion of the neck is shown in Figure 4; but this bird has not completed the bow. Normal birds in bowing give the impression of bringing the head lower than horizontal, but this effect is due to the puffed-out feathers of the neck and crop region. Naked birds, once mated, follow a normal sexual cycle, even to serious though futile attempts to incubate the eggs. Their lack of natural insulation makes it imperative that the birds be kept warm. Our only attempt to provide them with artificial clothing, however, was unsatisfactory: they objected strenuously to the "sweaters" knitted for them. We have perforce left them naked, but have taken care that their cages are near a radiator where they will always be warm. Under these conditions their body temperatures (taken *per anum*) are well within the range normal for the pigeon. We have made no attempt to ascertain the physiological or morphological consequences of their undoubtedly abnormal heat loss, comparable to the studies of Landauer and others on the frizzle fowl.

The naked condition in the pigeon is more uniform in expression and more extreme than the condition described by the same term in the domestic fowl.[1,2] Nakedness in the fowl depends on a sex-linked semi-lethal recessive factor. The nude chicken described and photographed in the Peruvian Andes by Mr. William La Varre, referred to by Hutt and Sturkie,[2] would seem, however, to be phenotypically comparable to these naked pigeons. Warren[3] has described "featherless" fowls apparently homozygous for the autosomal dominant "flightless," which is usually lethal when homozygous. These birds show somewhat more feathering than do the naked pigeons. The "featherless" chickens have deformed beaks and toenails, while naked pigeons are normal in these respects.

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Table I. Summary of F_2 mating (B558) from male B479A (Na na B^1B Cc) x female (Na na B- Cc)

Total eggs	Mortality					Survivals											Totals							
	Broken	Infertile	Dead embryo	Dead less than one mo. of age		Naked		Normal									Sex		Feathering		Color		Pattern	
								Red				Blue												
								Check			Bar		Check		Bar									
				♂	♀	♂	♀	♂	♀	?	♂	♀	♂	♀	♂	♀	♂	♀	Na	na	Red	Blue	Check	Bar
33	1	2	13	1*	1*	4	0	1	1	1	1	1	3	2	0	1	10	6	11	4	5	6	8	3

* Normal down.

CROSSINGOVER IN SPAGHETTI CHROMOSOMES

A Demonstration Project in Cytogenetics

WARREN P. SPENCER
College of Wooster

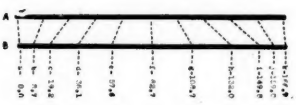
GENETICS is not recommended for the dull student. Those normally endowed with mental acuity, and even the gifted are often helped in grasping the concepts of genetics by visual aids. Photographs and diagrams are liberally used in the better texts. The *Journal of Heredity*, with its many fine illustrations, is a particularly valuable supplement in an introductory course in Genetics. His own considerable teaching experience convinces the author that many concepts of genetics, and particularly of cytogenetics, are even better illustrated by the use of three-dimensional models. From time to time this *Journal* has published descriptions of such teaching aids.[1,2] In our introductory laboratory course we have used chromosome models as described by Newcombe and Wilson.[2] Students are also given a project in which models are made from dyed pipecleaners, rubber bands, and metal staples to illustrate synapsis; tetrad stages with reduction and equation divisions without crossingover; single crossovers; double crossovers of regressive, digressive, and progressive types; triple crossovers of various types; simple inversions, included inversions and overlapping inversions. To illustrate segmental interchanges in Datura and other forms, wooden models of chromosomes, colored, and numbered, are used. Modifications of all these have been used in other laboratories and they are in various forms part of the basic armamentarium of genetic instruction.

For some years we have used a unique laboratory project to demonstrate crossingover, the construction of genetic maps, comparison with cytological maps, coincidence and interference. Several pounds of spaghetti in bulk are heated for a short time. On cooling this is quite brittle. Each student is given a supply of this spaghetti and a sheet of coordinate paper. He then breaks 50 sticks each about 20 cm. long. In the middle of each stick a section 10 cm. long is marked off in centimeters and these sections numbered consecutively from 1 to 10. The marking and numbering is done with a sharp pencil.

Each stick is then held at the ends and bent slowly in a bow until it breaks. The broken pieces are then laid on the coordinate paper and the points of breakage marked on a line at the top of the paper. Above this line the 10 regions are numbered consecutively. The next stick is then broken and recorded on a line 4 mm. below the first. All sticks are thus broken and recorded. These sticks represent the recovered strands from a crossover experiment in which 11 genes equally spaced along a cytological map are being followed. When a stick breaks outside the marked region, that is at either end, it represents a noncrossover strand; when it breaks once in the marked region a single crossover, etc.

When the row data have been secured each student counts the number of breaks in regions 1, 2, 3, etc. He then makes up a genetic map on a scale of 10 crossover units to the centimeter, placing the genes *a* to *k*, and giving the locus of each gene. Above this is placed a cytological map drawn to the same scale, but with the genes evenly spaced. Lines are then drawn from corresponding loci in one map to those in the other. Students compare their maps and note differences due to the small sample (50 chromosomes) used.

Each student also fills in from his raw data a table of double crossingover in



SPAGHETTI CROSSOVER MAP
Figure 5

A—"Cytological map," showing ten equally spaced genes. *B*—"Linkage map," based on breakage-data from 1,000 spaghetti "chromosomes," showing the distribution of these "genes." The crowding of the "genes" toward the end of the chromosomes is occasioned by fewer breakages in these regions.

regions 1-2, 1-3, ... 9-10. As these data are too fragmentary in themselves, all crossover data from the class are combined and the coincidence for each two regions involved is determined from all the data. The calculations are divided among the several members of the class; the final records are then mimeographed and each student given a copy. The principles illustrated by this cooperative laboratory project are then discussed.

To facilitate calculations we break an even 1,000 chromosomes. The results are best illustrated by giving a sample of the data. In Figure 5 are shown the cytological and genetic maps secured last year. It will be noted that there is a tendency for the genes to be clumped at the ends of the chromosomes, a result of less crossingover in these regions. Table I gives the coincidence and interference data from the same material. It will be noted that coincidence is low in adjacent regions, rises to unity or above for regions more distant, and then falls again. Table II gives a summary of multiple crossingover in another batch of 1,000 chromosomes. The experiment might be simplified by following fewer regions.

TABLE II. Numbers of crossovers per chromosome in 1000 chromosomes.

Number of crossovers in a chromosome	Number of chromosomes
0	16
1	408
2	402
3	149
4	22
5	1
6	2

TABLE I. Double crossingover and coincidence in spaghetti chromosomes. Total of 1000 chromosomes. Note-Coincidence is the ratio of the actual doubles to the expected doubles if all breaks were distributed at random, and is expressed as a decimal.

Regions involved	Expected doubles	Actual doubles	Coincidence	Regions involved	Expected doubles	Actual doubles	Coincidence
1-2	9.135	4	.438	3-10	13.013	7	.538
1-3	14.703	10	.683	4-5	53.965	2	.0389
1-4	18.705	24	1.283	4-6	55.900	30	.537
1-5	21.837	20	.916	4-7	49.795	73	1.466
1-6	22.620	17	.751	4-8	40.270	36	.894
1-7	20.271	14	.691	4-9	19.780	13	.657
1-8	15.486	10	.646	4-10	16.555	12	.724
1-9	8.004	4	.499	5-6	65.260	2	.030
1-10	6.699	2	.298	5-7	58.483	29	.496
2-3	17.740	1	.056	5-8	44.678	61	1.365
2-4	22.570	18	.789	5-9	23.092	29	1.255
2-5	26.355	29	1.100	5-10	19.327	15	.776
2-6	27.300	23	.842	6-7	60.580	0	.000
2-7	24.465	22	.899	6-8	46.280	36	.778
2-8	18.690	18	.963	6-9	23.920	22	.919
2-9	9.660	10	1.035	6-10	20.020	18	.899
2-10	8.085	6	.742	7-8	41.474	4	.096
3-4	36.335	4	.110	7-9	21.436	10	.466
3-5	42.419	31	.731	7-10	17.941	24	1.337
3-6	43.940	56	1.274	8-9	16.376	1	.061
3-7	34.377	23	.669	8-10	13.706	4	.292
3-8	30.082	20	.665	9-10	7.084	0	.000
3-9	15.548	12	.772				

The writer is aware that sometimes analogies may be more difficult to explain than the principles they illustrate. However, this experiment has proved quite helpful in clarifying certain concepts. It should be added that in our laboratory cooperative class projects dealing with four- or five-point crosses in Drosophila are later carried through and the results compared with the spaghetti chromosome experiment. The effect of high temperature in increasing crossingover in Drosophila may be illustrated. The amount of crossingover in a batch of spaghetti depends upon the length of time it is heated before being used.

Summary

A cooperative laboratory project for an introductory course in Genetics is outlined. By the preparation and manipulation of spaghetti chromosome models the following cytogenetic principles are demonstrated: (1) the physical nature of the chromosomes as rod-shaped bodies with tensile properties; (2) similarities in the order of genes in cytological and genetic maps; (3) differences in the spacing of genes in these two maps; (4) variations in coincidence along a chromosome, with nodes and internodes of interference; (5) effect of temperature on crossingover.

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✦

Quartermaster Corps Acquires Valuable Kellogg Arabian Stud Farm in Pomona

THE valuable Kellogg Stud Farm at Pomona, California, consisting of approximately 750 acres, together with Mr. Kellogg's own adjoining 50-acre modern ranch, both valued at more than $2,600,000 have been acquired by the Government for the use of the Remount Branch of the Quartermaster Corps, the War Department has announced.

This nationally-known horse breeding establishment has been donated by Mr. W. K. Kellogg of Battle Creek, Michigan, with the approval of the Board of Regents of the University of California who have been holding it in trust for a number of years. The donation of the ranch itself, of course, is made possible through Mr. Kellogg's generosity and foresight.

The Kellogg gift provides the Quartermaster Corps not only with approximately 800 acres of pasture and cultivated land and a number of valuable modern improvements, but with an Arab band consisting of over forty-five (45) purebred Arab mares and twenty-seven (27) purebred Arabian stallions. This band possesses some of the oldest and finest Arab blood in the world. Percherons, ponies and cattle are also included.

The Depot will operate primarily for the purpose of breeding, raising and issuing purebred Arab stallions for service. In addition it will dispose of any surplus stock from time to time by public sale in accordance with existing regulations and will maintain liaison with the Arabian Horse Club of America in order to insure that any surplus animals offered for sale will be appropriately used thereby preventing dissipation of Arab horse blood for other than breeding purposes.

Buildings include a number of modern, fireproof stables. The premises are equipped with the latest type farm equipment. The main stable contains 30 stalls, administrative offices, tack rooms and forage spaces, frame stable house, work animals and farm equipment.

PREVALENCE OF "WRYTAIL" IN CATTLE

Further Studies on the Prevalance and Mode of Inheritance of Wrytail in Cattle*

F. W. Atkeson, Franklin Eldridge and Heman L. Ibsen

WRYTAIL is a malformation consisting of a distortion of the tail head, the base of the tail being set at an angle to the backbone instead of in line with it. This abnormality is discriminated against by purebred dairy cattle breeders because the approved score card prescribes — "Tail head slightly above and neatly set between pin bones," and "Wrytail—serious discrimination." In 1935 Atkeson and Warren† reported the inheritance of wrytail in three related herds. By tracing the recurrence of this character in a limited number of cases through four generations they postulated that the character was inherited as a single factor recessive to normal tail setting. The character was studied in Jersey cattle, but the authors were not in a position to estimate the prevalence of the character in that breed or to state positively whether the character occurred in other breeds.

Information on the prevalence of wrytail among Jersey cattle has recently been collected from ten herds in Kansas, Missouri, Texas and Colorado. The occurrence of wrytail among other breeds has also been recorded. One hundred seventeen animals with wrytails were found in the ten Jersey herds. An analysis was made of the mode of inheritance in three of the herds which had a total of 73 affected animals.

Confirmation of Recessive Mode of Inheritance

In very few cases among the animals studied have the characteristics of both the parents been observed with respect to the tail condition. The genealogy of abnormal and normal animals occurring in three herds is presented in the pedigree chart (Figure 7). Data were recorded for other animals in these herds but those represented on the chart were limited to those sires which had sufficient numbers of offspring to permit illustration of the mode of inheritance. Tabulation of the number of wrytailed and normal animals observed in the ten herds is presented in Table I. Also included are data on several sires in herds 1, 2 and 3 which are not presented in Figure 1 because of limited numbers of offspring.

The fact that wrytailed offspring were produced when both parents appeared normal fits the assumption that the character is inherited as a recessive. Representing wrytail by *wt* and normal by *Wt*‡, both of the normal appearing bulls Nos. 1 and 2 must have been *Wtwt*, or heterozygous for the character. When bull No. 1 was bred to seven wrytailed cows (Figure 7) only two of the nine offspring were wrytailed. The deviation from the expected 1:1 ratio, however, is not statistically significant.

Estimated Wrytail Gene Distribution Among Jersey Cattle

An estimate was made of the gene frequency, based on the data accumulated in the ten herds. In a recessive character, the gene frequency mathematically is the square root of the proportion of times the character is observed in a population, provided a single factor character is involved. The theory of gene

*Contribution No. 150 from the Department of Dairy Husbandry and No. 151 from the Department of Animal Husbandry, Kansas State College, Manhattan, Kansas.

†Atkeson, F. W., and T. R. Warren. "Inheritance of Wrytail in Jersey Cattle." *Jour. Hered.* 26 (8) 331-334. 1935.

‡Atkeson and Warren (1935) used the symbols *N* and *n* for this character.

VARIATION IN WRYTAIL
Figure 6

A—Shows a rather typical case of left wrytail, *B*—an extreme deviation of the base of the tail to the right. There appears to be no genetic determination of the direction of the deviation.

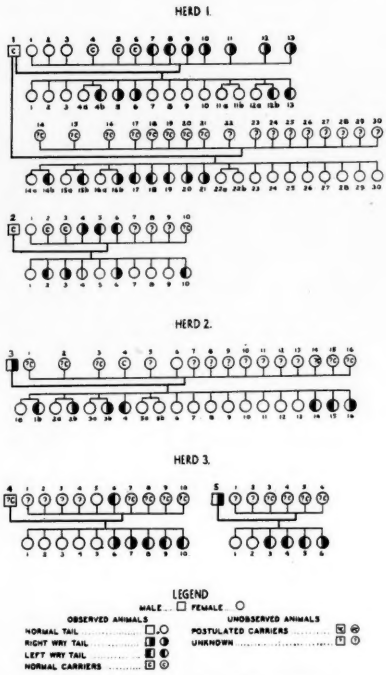
frequencies is also based upon the assumption of random matings. The data from the ten herds were combined in order to establish a general figure. The estimated frequency of the wrytail gene was 57.8 per cent.

An important estimation that can be made from the gene frequency is the number of carriers, or heterozygotes, not showing the character. For example, in the ten herds the gene frequency was 58 per cent. Therefore, in the 350 head of cattle there would be 700 homologous chromosomes concerned with the wrytail character, of which 406 would carry the gene *wt*. Of these 406, however, 234 would represent the 117 wrytailed animals found in the herd. This would leave 162 *wt* genes distributed among the remaining 234 animals (*Wtwt*), only 71 animals of the 350 thus being non-carriers (*WtWt*).

The fact that of the 350 animals observed in the ten herds 117, or 34 per cent, were homozygous for the wrytail character, 162, or 46 per cent, were probably heterozygous, and only 71, or 20 per cent, were non carriers, indicates the degree to which this gene is disseminated through these herds. The herds investigated should not be considered typical of the Jersey breed, since part of them were selected because of the high incidence of the character in them.

Additional evidence of the wide dissemination of the *wt* gene is the fact that of the 27 bulls in herd No. 1 represented by progeny, 16 sired one or more of the 47 wrytail animals. Since both parents must carry the factor for the recessive character before it will show in the offspring, at least 59 per cent of the bulls were carriers. Some of the remaining 11 bulls may also have been carriers, but did not have sufficient offspring to be fully tested. In the case of some of the 27 bulls it was not definitely known whether they themselves were wrytailed or not.

Bulls No. 3 and No. 5 were both wrytailed and both "wry" to the right (Figure 6*B*), but each sired both left and right wrytailed daughters. Also among eight dam-and-daughter comparisons three dams which were "wry" to the left produced daughters "wry" to the right, and five dams which were "wry" to the right produced daughters "wry" to the left. The two wrytailed bulls, however, produced both types of wrytails, and the deviation from the expected random occurrence of 1:1 in the direction of the tail-set among all wrytailed animals was not significant. This evidence seems to indicate that the direction of tail-set is non-genetic in character.



WRYTAIL IN THREE HERDS

Figure 7

Composite one-generation pedigree chart showing frequency of occurrence of wrytail in 83 known matings involving five bulls in three herds. The progeny of the respective dams is given directly below them in the chart. A single recessive gene is believed to be involved in the production of this defect.

Occurrence of Wrytail in Other Breeds of Dairy Cattle

Since becoming interested in this character the authors have especially observed herds of other breeds of cattle to determine in which breeds wrytail occurs. The fact that Atkeson and Warren were not positive whether other breeds than Jerseys had wrytailed animals, would indicate that the character is at least less frequently observed in other breeds. An extensive survey of 34 herds of Brown Swiss cattle selected at random showed that the incidence of the gene for wrytail was almost as high as among the Jersey herds studied . Among the 34 herds, representing 505 animals, there were 101 wrytailed animals (20%) and a gene frequency for wrytail of 44.7 per cent. When the 505 animals were grouped according to genetic classes, there were estimated to be 101 *wtwt*, 249 *Wtwt* and 155 *WtWt*. Although genealogy charts are not presented, instances were found where normal parents produced wrytailed off-spring. This fact, together with the incidence of the character in the breed, indicates that the gene for wrytail is inherited in the Brown Swiss breed as a single factor recessive, as in the Jersey breed. The slightly lower gene frequency in the Brown Swiss breed is of doubtful significance because the Brown Swiss herds were selected at random while such was not the case in part of the Jersey herds. In the Brown Swiss breed part of the wrytails were set to the left and part to the right but the proportion set to the right was greater than among the Jerseys.

Although no extensive survey has been made of other breeds, observations indicate that the character is found in Guernseys, Holsteins and Ayrshires with the relative frequency in the order given. Wrytails have often been seen in Guernsey herds and in one herd of 17 there were four wrytailed cows, two with tails set to the left and two to the right. Two of the cows, one set to the left and one to the right, are maternal half-sisters. In the Holstein breed wrytailed animals were found in five herds in the following ratios: 1:17, 2:35, 1:39, 2:25 and 1:26. In one herd each of a pair of full sisters was wrytailed, one with tail set to the left and the other to the right. In another herd the two wrytailed animals, both set to the left, were maternal granddaughters of the same sire. Casual observations would indicate that wrytailed animals occur much less frequently among Ayrshires, although the character has positively been noted in this breed. Sufficient data were not available in breeds other than Jerseys and Brown Swiss to make possible the determination of the mode of inheritance.

Summary and Conclusions

1. Observations were made on the occurrence of wrytail among ten Jersey herds representing 350 animals. Among the 350 animals, 117 were wrytailed. Apparently the character is inherited as an autosomal recessive.

2. The wrytail gene frequency for the ten herds combined was 58 per cent. Of the total (350) animals it was known that 34 per cent were recessives, and it was estimated that 46 per cent were heterozygotes and 20 per cent homozygous dominants.

3. Of the 117 wrytailed animals, 64 were set to the right and 51 to the left, and two with direction unknown. The deviation from a 1:1 ratio is non-significant. The evidence indicates that the direction of the tail-set is non-genetic in character.

4. The wrytail character has also been observed in the following breeds: Guernsey, Holstein and Ayrshire. Casual observation indicates that the character occurs less frequently in these breeds than in Jersey and Brown Swiss. There is evidence that the character is inherited, but sufficient data are not available to determine whether the mode of inheritance is the same as in the Jersey and Brown Swiss breeds.

TABLE I. Summary of data collected on wrytail in Jersey cattle.

		Bull	Progeny Wrytail				Dams Wrytail					
Herd	No.	Con.	Nor.	Total	WR	WL	Nor.	Total	WR	WL	?	G. F.
1	1	N	24	13	5	8	7	9	7	2	21	
	2	N	6	4	2	2	3	3	1	2	4	
	6	?	2	6	3	3	2	2	0	2	4	
	7	?	3	5	2	3	3	1	1	0	4	
	Others		20	19	12	7	9	6	4	2	24	
	Total		55	47	24	23	24	21	13	8	57	67.9
2	3	WR	13	7	3	4	2	0	0	0	18	
	8	?	5	3	2	1	0	0	0	0	8	
	Others		32	3	1	2	2	0	0	0	33	
	Total		50	13	6	7	4	0	0	0	59	45.5
3	4	?	5	5	2	3	0	1	0	1	9	
	5	WR	2	4	1	3	0	0	0	0	6	
	Others		6	4	3	1	0	2	1	1	8	
	Total		13	13	6	7	0	3	1	2	23	70.7
4	Herd		25	2	not recorded		9	0	0	0	18	27.2
5	Herd		31	12	10	2		not recorded			43	52.8
6	Herd		14	8	5	3	6	0	0	0	16	60.3
7	Herd		5	3	1	2		not recorded				61.2
8	Herd		13	8	5	3		not recorded				61.7
9	Herd		2	4	1	3		not recorded				81.8
10	Herd		25	7	6	1		not recorded				46.8
Grand Total			233	117	64	51	43	24	14	10	216	57.8

(Con. = condition; N = normal; ? = unknown; WR = wry right; WL = wry left; G. F. = gene frequency.)

LAST GLIMPSES OF THE EAST INDIES

IN the previous delightful work, *The World Was My Garden,* David Fairchild gave us far more than an incurably enthusiastic plantsman's account of his collecting journeys. The book was also a panorama of much contemporary history at home and abroad, in terms of the people who were making it, seen through a genial plantsman's eyes. This was projected against a background of the fascinating and still too little known plant world, and its contribution to man's economic and social life.

In the same way, *Garden Islands of the Great East** is more than the account of the author's latest plant-collecting trip which the outbreak of war unfortunately terminated midway in its itinerary. Here is pictured the pioneering of Dutch scientists in the Netherlands East Indies and of American scientists in the Philippines, whose labors have had such a direct bearing on the current war. A striking contrast is presented between the well-developed and amply-supported Dutch programs dealing with rubber and cinchona and our own pathetically little and late and starveling efforts in the Philippines and in our other tropical possessions. Here we have the real reason why we are still searching feverishly in the middle of a war for information about so wide a range of tropical plant products now vital in our every war effort. Rubber, cinchona and manila hemp are but three of a long list of botanical bottlenecks we are frantically trying to uncork in strange locations and in too deep a jungle of ignorance.

It is fitting that much of the volume is devoted to the pioneering efforts in the Philippines of such scientists as Curran, Baker, Ahern, Fisher, Merrill and others whose contributions have since the turn of the century laid so much of the foundation for a free and enlightened Philippine nation.

Garden Islands of the Great East remains first and foremost a plantsman's book about plant hunting. Infectious enthusiasm about plants and plant forms has been a life-mark of David Fairchild. This trip really began in 1895 when with Barbour Lathrop he skirted these islands and gained fleeting and enticing glimpses of an unexplored hinterland. He returned nearly a half century later, under the shadow of war, to find larger quantities of exotic material and to collect it in a more bizarre and colorful locale, than in any of his other explorations. Best of all, there is promise that a large proportion of the hundreds of forms collected will become established in the gardens of the warmer parts of our own country. We can also be sure that many of them will add to the beauty of the gardens and to the diversity of the agriculture of the American tropics south of us. To attempt to pick out for special mention some of the more striking forms would require a list beyond the limits of a review—and the reader should not be subjected to a reviewer's partiality. He should have the joy of doing this for himself!

The expedition probably carried the last Americans through and out of the Celebes and Moluccas before the war clouds closed over these strange and teeming islands. It is good to have this vivid and nostalgic account by a keen and sensitive observer with a unique sense of the historical background. Islands so remote that even Dutch scientists had never visited or surveyed them, have had in the dark days of 1942 and will have again the sharp thunder of air, sea, and land combat suddenly bursting upon them. Many of the spots whose beauty enchanted our author will probably become in the months ahead battlefield stepping-stones in the march toward Tokyo. We may next hear of them from our own boys whose observations will be those of fighting youth in plane, submarine, warship, or ranger battalion.

No other plant explorer has been so

*Garden Islands of the Great East, by David Fairchild. $3.75. Charles Scribner's Sons, New York. 1943.

fortunate as David Fairchild in his seafaring friendships. Where Bligh's *Bounty* was a warship provided by the British Government specifically to hunt breadfruit, David Fairchild has been able to diversify his travels in time, space, and taxonomy through the untrammeled explorations made possible by private support. In the 1920's, Allison Armour rebuilt the freighter *Utowana* as a botanical transport and this first plant-explorer's ship took David Fairchild on several expeditions to Europe, Africa, and the American tropics. And this last expedition would have been impossible without the interest of Mrs. Anne Archbold, who put at Dr. Fairchild's disposal an especially built Chinese junk, the *Cheng-Ho*. Equipped with Diesel engines, this unique craft was ideal for traversing an island-dotted sea. In times when scientific plant research still suffers from limited support, it is fortunate there are enthusiasts of private means who get real satisfaction in making such trips possible. Science in many fields is greatly in their debt.

As the journey marked the close of an era in the Philippines and the Dutch East Indies, so also it marked the beginning of a new era in plant exploring. Bringing plants back alive has always been a major headache to the plant explorer. From Bligh's day to the present the plantsman has been the slave of Wardian cases and of elaborate—and all too often futile—rituals of botanical artificial respiration. The phytal statistics of most plant expeditions have made grim reading indeed. In contrast the seeds and cions collected by Dr. Fairchild on the *Cheng-Ho* were despatched by air and arrived in Florida, half way round the world, in a matter of days. This is a far cry from the weeks and even months heretofore required for transporting plant immigrants to their new homes. The present war has been marked by shipments of plant material on a scale never before attempted. Fisher's flight with the cinchona seed from the Philippines is perhaps the most striking example, along with the despatch by air of large amounts of high yielding clons of rubber from the East Indies to the West Indies ahead of the Japanese invasion. Air transport and air conditioning will make revolutionary changes in plant exploring in post war days, for the network of airways developed by our armed forces will make peacetime trips to any corner of the globe a matter of hours.

Changing and modernizing of plant transportation can hardly reduce the thrill and the romance of plant exploring and introduction. It remains one of the most satisfying careers for a plantsman. As Alfred Russel Wallace's *Malay Archipelago* lured David Fairchild on through the years, so may his own *Garden Islands of the Great East* prove a stimulation to some budding plantsman of today, to entice him into as fascinating and as productive a life as can lie ahead of any plant scientist when peace again returns.

David Fairchild's vivid word pictures are supplemented by the large number of unusually excellent photographs, many of them by Edward Beckwith, a member of the expedition,—the others by the author. The end maps give a picturesque outline of the area visited, and many of the odd names may be looked for in the months ahead as the tidal wave of war rolls northward and allied forces drive back the Japanese.

KNOWLES RYERSON

CYTOLOGICAL STUDIES OF A TRIPLOID PERENNIAL RYEGRASS AND ITS PROGENY*

W. M. MYERS†

THERE have been numerous reports in the literature of meiotic behavior in triploid plants, the results of the investigations having contributed valuable cytogenetical information regarding the species investigated. Studies of triploids also have provided evidence relative to chromosomal behavior during meiosis. In the genus *Lolium*, meiotic behavior of a triploid has been reported in only one instance. From a cross of *Lolium loliaceum* × *L. rigidum*, Jenkin and Thomas[5] obtained a 21-chromosome plant that apparently had one genome from *L. loliaceum* and two genomes from *L. rigidum*. Because of the lack of such information for perennial ryegrass (*Lolium perenne* L.), cytological investigations of an autotriploid ($x = 7$) of this species seemed desirable. Autotetraploid plants of perennial ryegrass were obtained by treatment of germinating seeds with colchicine.[9] One of these plants was allowed to flower in the greenhouse adjacent to a number of diploid plants and a single seed was obtained. The plant developed from this seed was a triploid.

Materials and Methods

The triploid plant was increased vegetatively in the greenhouse and was induced to flower during the winter by use of supplementary illumination to provide a 16-hour daily light period. Microsporocyte material was fixed in acetic-alcohol and stored in this solution at low temperature until examined. All examinations of meiotic behavior were made from fresh aceto-carmine smear slides.

When the plant commenced to flower it was surrounded by diploid plants which also were shedding pollen. The triploid plant failed to set seed with its own pollen when isolated; therefore, all seeds obtained in the greenhouse were assumed to have been produced with pollen from normal diploids. The seeds produced on the triploid were germinated and the seedlings were transplanted individually in four-inch pots. Chromosome numbers of these progeny plants were determined from aceto-carmine smears of microsporocytes. Because of technical difficulties, chromosome counts from root tips of perennial ryegress have been somewhat less reliable than those from microsporocytes; hence the use of the more laborious method.

Experimental Results

Meiosis in the Triploid

Mid-prophase: On the hypothesis of synapsis in pairs of homologous chromosome segments, there are expected at mid-prophase in an autotriploid equal lengths of paired and unpaired chromosomes. In the perennial ryegrass triploid, on the other hand, there was a preponderance of paired and a deficiency of single strands. In fact, in some sporocytes (Figure 8*A-B*), unpaired lengths were rare. The maximum incidence of single threads that was observed is illustrated in Figure 8*C*. Association of more than two chromosomes at any particular level was never observed. Consequently, the paired regions in excess of the expected one-half must have resulted from the synapsis of chromosome seg-

*Contribution No. 52, of the U. S. Regional Pasture Research Laboratory, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, State College, Pennsylvania, in cooperation with the northeastern states.

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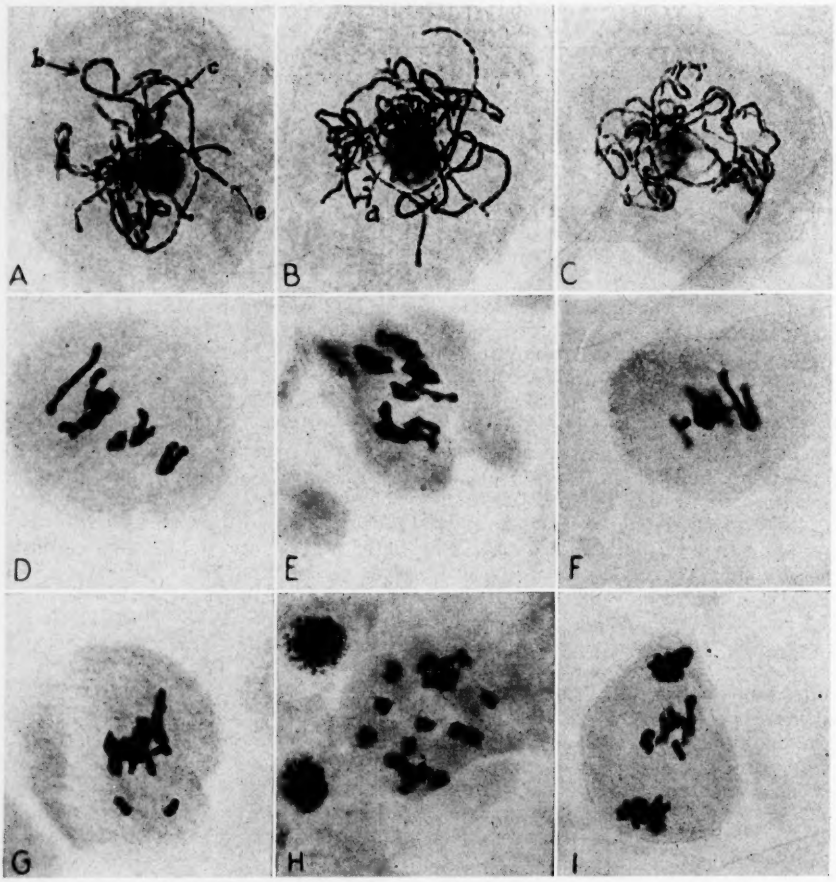
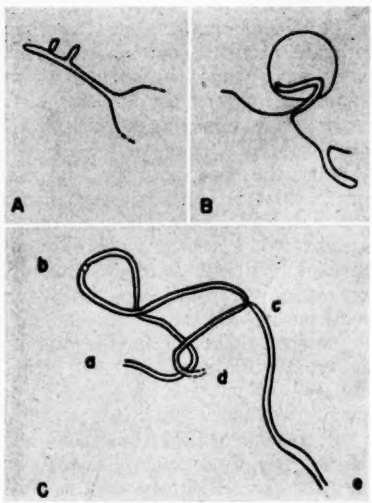


MEIOSIS IN TRIPLOID PERENNIAL RYE GRASS

Figure 8

A, B and *C*—Mid-prophase figures showing a preponderance of paired elements, and a deficiency of single chromosome lengths. This is indicative of non-homologous pairing. *D* and *E*—Metaphase I showing types of trivalents. *F*—Univalent chromosomes at Metaphase I, oriented on the equatorial plate. *G*—Shows three univalents at Metaphase I. One lies near the equatorial plate, and two are near one pole. *H*—Four univalents at Anaphase I that are lagging and dividing equationally. *I*—Shows a similar situation at Anaphase I, wherein five univalents are involved. (About ×900.)

ments that are not ordinarily considered homologous. In some instances this involved pairing of such segments from different chromosomes. An example of this type is illustrated in Figure 9*C*, a camera lucida sketch of a configuration found in Figure 8*A*. In this case there was homologous pairing from *a* to *c*, evidence for this being the equal ends at *a*, the uniformity of pairing throughout and the presence of the centromeres at the same level at *b*. At *c* the previously synapsed chromosomes exchanged partners. One of the chromosomes was paired from *c* to *e* with a third chromosome while the other was paired from *c*



ILLEGITIMATE PAIRING
Figure 9

Camera lucida sketches of types of illegitimate pairing encountered at mid-prophase in triploid perennial rye grass. *A*—Shows fold-backs within a chromosome. *B*—Shows similar fold-backs in one of the nucleoli chromosomes. *C*—Diagrams pairing involving three chromosomes. The pairing from *A* to *C* is of homologous elements. That from *C* to *D* is probably homologous, and from *D* to *E* is non-homologous. (Magnification about ×3200.)

to *d* with the third chromosome. The paired strands were lost in a tangled mass of chromosomes at *d* and, consequently, could not be traced to the end. The third chromosome probably was the homologue of the first two. If so, either the synapsis from *c* to *d* or from *c* to *e* was homologous, the other being non-homologous. It was impossible to determine which was homologous. The only departure from normality was a slight looping apart of the paired strands near *e*.

Two cases of synapsis of segments within the same chromosome are illustrated in Figure 9*A-B*. Figure 9*A* also is shown in Figure 8*B*, at *a*. In this case the single chromosome had folded back and then within the fold were two smaller loops. In Figure 9*B*, one of the nucleolar chromosomes was involved. The chromosome had folded back at the nucleolus organizer, the short arm synapsing with a long arm through about one-half of the length of the former. In the distal part of the long arm there was another fold back. In the cases illustrated in Figures 9*A* and *B*, the illegitimate pairing could not be distinguished by appearance from legitimate pairing in other chromosomes. Of the numerous cases that were identified as illegitimate pairing, there was a considerable preponderance of types in which segments of the same chromosome were synapsed. Since this type of pairing is much more easily identified than that between different chromosomes, it is unsafe to conclude that it occurs more commonly. It was impossible to analyze a complete nucleus in any case. Consequently, comparable quantitative data on the relative frequencies of illegitimate pairing between and within chromosomes could not be obtained.

The type of illegitimate pairing found in these investigations seems to be similar to the non-homologous pairing observed by McClintock[7] at mid-prophase in maize. Similar pairing behavior was reported by Jenkin and Thomas[5] in triploid *Lolium loliaceum* × *L. rigidum*. McClintock[7] postulated two forces conditioning synapsis, namely (1) an attraction between homologous parts, and (2) a tendency for chromosomes to occur in pairs, resulting in an attraction between single strands even if not homologous. Hence, in the absence of homologous segments, there would assumedly be a tendency for non-homologous parts to synapse. Jenkin and Thomas,[5] however, attribute non-homologous association to "torsional pairing."

Although it has been assumed that the illegitimate pairing involved non-homologous chromosome segments, there is the possibility that these segments were partially homologous. Gates[4] and his students have concluded that at least some of the species of *Gramineae* with a basic chromosome number of seven are secondary polyploids derived from types with the basic number of five. They cite as evidence favoring this hypothesis the

fact that many of the diploid *Gramineae* species with x = 7 have two nucleolar chromosomes in the haploid complement. Perennial ryegrass, likewise, has two nucleolar chromosomes. If the hypothesis of Gates[4] and others is correct there would be expected among the seven chromosomes of the haploid set numerous duplications both within and between chromosomes; hence, illegitimate pairing would be expected to occur.

As Bhaduri[1] has pointed out recently, the evidence for secondary polyploidy derived from the presence of two nucleolar chromosomes is not critical. Two nucleolar chromosomes in the haploid set also could have arisen by reciprocal translocation involving a break at the nucleolus organizer in the manner observed in maize by McClintock.[8] In regard to the hypothesis of homologous segments, the type of illegitimate pairing within chromosomes is of some importance. This pairing was limited, so far as could be observed, to simple fold backs of the sort illustrated in Figures 9*A* and *B*. Therefore, if this pairing is to be attributed to homology, it is necessary to assume that the duplicate segment was inverted in each case when inserted into the chromosome.

Metaphase I: Among 164 metaphase I sporocytes observed, 41.5 per cent had seven trivalents (7_{III}), 32.3 per cent $6_{III} + 1_{II} + 1_{I}$, 19.5 per cent $5_{III} + 2_{II} + 2_{I}$, 4.9 per cent $4_{III} + 3_{II} + 3_{I}$, and 1.8 per cent $3_{III} + 4_{II} + 4_{I}$. No configurations other than trivalents, bivalents and univalents were observed. Furthermore, the total of bivalents plus trivalents equaled seven in all observed cases. Darlington[3] has diagrammed the four types of trivalents that are possible from normal pairing of three homologues. In this material, types 7 and 9 were most common (Figure 8*D* and *E*) and type 8 was observed rarely. Type 10 was not identified in the sporocytes examined. No trivalent configurations other than these basic types were observed. The conformity of the trivalent types to those expected from normal pairing, together with the absence of sporocytes with more than seven trivalents plus bivalents, indicates that the illegitimate prophase pairing was rarely if ever accompanied by chiasma formation. In this regard, the behavior of this material agrees with that reported in maize by McClintock.[7]

Among the sporocytes examined, the average chiasma frequency per chromosome was 1.42. This is lower than has been observed by the author[10] in diploid perennial ryegrass. In the autotriploid, however, only two-thirds of the chromosome length can be involved in homologous pairing. Correcting the obtained chiasma frequency on this basis gives a calculated value of 2.13. The highest chiasma frequency obtained among 19 diploid plants was 2.11 per chromosome. Consequently, the frequency of chiasmata per unit of paired chromosome is slightly higher in the triploid than has been observed in diploid plants. The data are not strictly comparable, however, since the plants were unrelated and the data were collected at different times.

Of the univalent chromosomes observed, 71 per cent were oriented on the equatorial plate prior to the initiation of anaphase I (Figure 8*F*). Many of these were already beginning to divide longitudinally. An additional 24 per cent were lying near the equatorial plate but were not oriented on it. An example of this is illustrated in Figure 8*G*. No evidence of the equational split was observed in the univalents found in this position. Five per cent of the univalents were lying outside of the spindle near one of the poles. (See two univalents in Figure 8*G*.) Univalents of this sort appear to be in a position to be included in the daughter nuclei at interphase. This probably accounts for some of the deficiency of anaphase I laggards compared with metaphase I univalents that is found in diploid perennial ryegrass.[10]

According to Darlington,[3] Jenkin and Thomas[5] and Levan,[6] univalents usually lie outside of the spindle at metaphase I and either do not congress or do so later than the bivalents. In contrast with this, Levan[6] reported regular congression of the univalents in asynaptic *Allium am-*

plecten and Myers[11] found the univalents regularly oriented on the equatorial plate along with the bivalents in the hybrid *Phleum pratense* × *P. subulatum*. The univalent behavior in triploid perennial ryegrass is intermediate in that regard, being similar to the behavior found in diploid plants of the species.[1]

Anaphase I. At anaphase I, 103 sporocytes were examined for presence of lagging and equationally dividing univalents. Of these 37 per cent had none, 26 per cent one, 17 per cent two, 9 per cent three, 9 per cent four (Figure 8*H*), one per cent, five (Figure 8*I*), and one per cent six. The average number of laggards per 100 sporocytes was 133 compared with 93 univalents per 100 sporocytes at metaphase I. The most probable source of the excess of anaphase I laggards is improper disjunction of the trivalents. Occasional cases were seen at very early anaphase I in which the chromosomes of a trivalent had disjoined in such a manner as to leave one chromosome on the equatorial plate. Darlington[2] reported a similar behavior of multivalents in the *Tradescantiae*. Excess of anaphase I laggards compared to metaphase I univalents has been observed also in *Dactylis glomerata*, an autotetraploid species.[13, 14, 15, 16]

It was possible to count the chromosomes in both groups in 21 of the anaphase I sporocytes in which no laggards occurred. The distribution was 10-11 in nine, 9-12 in five, and 8-13 in seven sporocytes. Among 100 groups of chromosomes, including sporocytes in which laggards were present, there were five with seven chromosomes, 11 with eight, 25 with nine, 32 with 10, 14 with 11, seven with 12 and six with 13. Thus the most frequent classes of pollen grains should be those with nine and ten chromosomes. About five per cent of the pollen grains would be expected to be haploid while the occurrence of diploid grains would be rare.

Quartets. Among 198 quartets, 26.8 per cent did not show micronuclei. One micronucleus was found in each of 8.1 per cent while the remainder had two or more, the maximum in any quartet being eight. There were 202.5 micronuclei per 100 quartets.

It has been shown that the loss of daughter univalents resulting from the division of lagging chromosomes at anaphase I is the most common source of micronuclei in orchard grass,[13, 14, 15, 16] in timothy,[12] and in diploid perennial ryegrass.[10] From an analysis of the types of quartets in relation to numbers of anaphase I laggards, Myers and Hill[14] concluded (1) that part of the daughter univalents from anaphase I laggards were included in the microspore nuclei and (2) that some micronuclei were formed due to abnormality of the second division itself. Substantiating evidence was obtained from a study of clones of orchard grass in which Myers[13] found by use of the analysis of co-variance that among clones there were significant differences in incidence of micronuclei which were independent of differences in anaphase I laggards. The behavior in the triploid perennial ryegrass plant is similar to that in orchard grass. In the quartets 72.3 per cent had micronuclei while only 68 per cent of the anaphase I sporocytes had laggards. On the other hand 266 micronuclei per 100 quartets were expected on the basis of number of anaphase I laggards[14] while only 202 were observed.

Progeny of the Triploid

From pollination of the triplod with pollen from diploid plants, 152 seeds

TABLE I. Numbers and percentages of plants with indicated chromosome number among the open-pollinated progeny of the triploid plant of perennial ryegrass.

	Chromosome Number					
	2x	2x+1	2x+2	2x+3	2x+4	Total
Number of plants	30	52	27	6	4	119*
Per cent of determined plants	25.2	43.7	22.7	5.0	3.4	100
Per cent of total plants†	23.1	40.0	20.8	4.6	3.1	91.5

*Total of plants of which the chromosome numbers were determined.

†Total plants (130) including those that died.

and, subsequently, 130 seedlings were obtained. Eleven of the seedlings were very abnormal in appearance and died before chromosome number determinations could be made. The chromosome numbers of the remaining 119 plants are shown in Table I.

Since the pollen parents were normal diploids, the chromosome numbers of the progeny plants provide a fairly reliable measure of the chromosome numbers of the egg cells from which the plants were produced. On this basis, the most common types were x, $x+1$, and $x+2$ while none with more than four extra chromosomes functioned. In comparison, the data from anaphase I indicated that there would be expected among the pollen grains only about five per cent of haploids, seven per cent with five extra chromosomes, and six per cent with six extra chromosomes, while the most common types would be those with two and three extra chromosomes.

The discrepancy between chromosome numbers at anaphase I and in the progeny probably arises from a combination of several factors: (1) It was shown that the relationship between anaphase I laggards and chromosome loss was not absolute; hence, chromosome numbers in the daughter chromosome groups at this stage would not be an exact criterion of the numbers to be expected in the microspore nuclei. (2) These investigations deal with meiosis in the microsporocytes and meiotic behavior in the macrosporocytes might be different. Such a difference has been observed by Satina and Blakeslee[18] and others. (3) The macrogametophytes with other than the haploid number probably are less viable than the haploid; this being particularly true for those with three or more extra chromosomes. (4) The aneuploid embryos probably are less viable than the diploid. The effects of (3) and (4) were evident from the much lower fertility of the triploid plant. Exact determinations were not made but it was estimated that the triploid set not more than five per cent as much seed as comparable diploid plants. Factor (4) might also cause a reduced seed germination. Of the seed obtained from the triploid, 85.5 per cent germinated. This is somewhat lower than has usually been obtained from seed of diploid plants handled in a similar manner.

In addition to the factors mentioned above there were 11 plants that died before the chromosome numbers could be determined. All of these plants were similar in appearance, having extremely narrow leaves, shorter stature, and insufficient root development to support the plants. A few other plants of this type survived to the flowering stage and these plants had reduced numbers of spikelets and abnormal floral development. Two of the latter plants, slightly more vigorous than the others, were trisomic; the remainder having two, three, and four extra chromosomes. In one plant of this type with three extra chromosomes, a normal appearing sector developed, which had two extra chromosomes. Apparently the plants of this type had one extra chromosome in common. Therefore, the 11 plants probably should be included among the aneuploids, decreasing the proportion of diploid plants to 23.1 per cent.

Random Distribution of Univalent Chromosomes

The random distribution of chromosomes of bivalents to the two poles at anaphase I is one of the cardinal principles in cytogenetics. The assumption of random distribution has been extended also to the extra chromosomes of triploids (Darlington[3]) and aneuploids. On the other hand, when this hypothesis was subjected to experimental test in triploid *Datura*, Satina and Blakeslee[17] found an excess of sporocytes in which a majority of the extra chromosomes passed to one pole and a deficiency of the more nearly equal distributions. In the triploid perennial ryegrass plant, the number of anaphase I sporocytes counted was too small to provide critical evidence regarding the hypothesis. However, it is perhaps suggestive that the relatively high frequency of 8-13 distributions is similar to the discrepancy found by Satina and Blakeslee.[17]

The hypothesis of random distribution of the extra chromosomes was tested using eight plants each with $2x+2$ chromosomes (Table II). The observed ratio did not deviate significantly from 1:1 in any case. Furthermore, total X^2, X^2_t and X^2_h were less than X^2 for P of 0.05 with appropriate degrees of freedom. The results, therefore, are in agreement with the hypothesis of random distribution where two extra chromosomes are involved.

Summary

1. At mid-prophase of an autotriploid perennial ryegrass plant there was an excess of paired and a deficiency of unpaired chromosome regions compared with expected. This was interpreted as resulting from non-homologous association.

2. At metaphase I, univalents occurred in 58.5 per cent of the sporocytes; the maximum number of univalents per sporocyte was four. The metaphase I univalents tended to lag and divide equationally at anaphase I. There were more lagging univalents at anaphase I than unpaired chromosomes at metaphase I, the excess of anaphase I laggards probably resulting from improper disjunction of trivalents.

3. Micronuclei in the quartets resulted from failure of the daughter univalents from anaphase I laggards to be included in a daughter nucleus either in the first or second division. There was evidence that some of the daughter univalents were included in the microspore nuclei and that some micronuclei were formed also as a result of abnormalities of the second division.

4. Among the functional eggs, as measured by chromosome numbers of the seed progeny of the triploid, there was an excess of haploid and a deficiency of aneuploid, particularly those with three or more extra chromosomes, compared with the frequencies expected from anaphase I distributions in the microsporocytes.

5. In $2x+2$ plants, the distribution of the two extra chromosomes at anaphase 1 was at random.

TABLE II. Distribution in $2x+2$ plants of chromosomes at anaphase I in sporocytes in which laggards did not occur.

Pot Number	No. of sporocytes with distribution of		X^2 for fit to 1:1
	7-9	8-8	
148	29	25	0.298
149	25	28	0.170
151	16	16	0.000
183	51	58	0.451
190	74	81	0.317
203	33	33	0.000
204	43	43	0.000
208	18	29	2.923
Total	289	313	0.598*

$* = X^2_t$. Total $X^2 = 4.159$. $X^2_h = 3.561$

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A PEDIGREE OF SEX-LINKED RECESSIVE PERONEAL ATROPHY

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THIS trait involves the inability to support weight on the heels or to lift the toes when standing on the heels. Consequently, the front part of the foot falls quickly to the floor with a characteristic click when the individual takes a step. Standing or walking for several hours causes severe pain in the foot, especially in the arch. This pain may be quite excruciating after prolonged use of the feet. The calf of the leg is somewhat atrophied, the degree apparently depending upon the age of the individual. Also, the fingers cannot be moved as freely as in the normal condition. When the hands are cold, manipulation demanding manual dexterity is practically impossible, and the individual cannot bring the thumb in contact with any of the fingers.

Allan[1] has reported three pedigrees of peroneal atrophy in man. Each pedigree indicates a different mode of inheritance, namely, a simple dominant, a sex-linked recessive, and a simple recessive. He further showed that the age at which an individual is first affected and the degree of disability varies with each type. If the trait is due to a dominant gene, it does not manifest itself until about the age of thirty, and is moderate in effect. Individuals are able to plough their fields and pick cotton past the age of seventy. Sex-linked peroneal atrophy affects boys by the fifteenth year. By the age of twenty-five, according to Allan, they are unable to continue in such occupations as watchmaking and bookkeeping, must use crutches or are bedridden. Those who suffer from the recessive form notice it by the age of eight and are helpless cripples by the second decade.

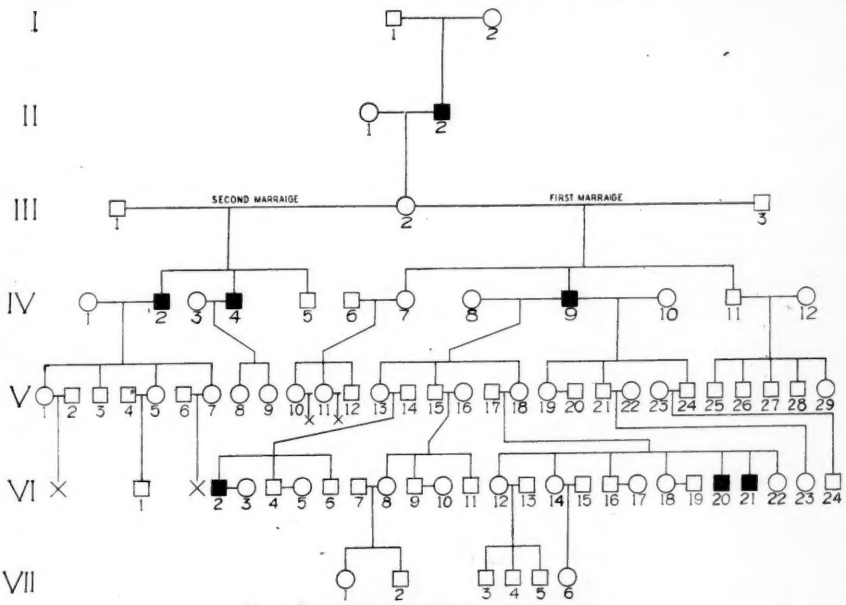
The accompanying pedigree is undoubtedly another case of the sex-linked recessive type of peroneal atrophy. This family was first called to the attention of the author by the fact that two brothers, both college students, were afflicted in the same manner. The data presented here were gathered through the cooperation of the older of the two boys (VI-20), his mother (V-18), and his great half uncle (IV-2).

The age at which the trait becomes evident in this family seems to coincide with that described by Allan in his sex-linked pedigree. Both of the brothers (VI-20 and VI-21) state that although they were aware of the fact that they had the trait at an earlier age, the syndrome was not evident to the casual observer until they were about fourteen years old. However, neither can remember the time when he could stand or walk on his heels. The age at which the individual becomes incapacitated in this pedigree does not agree with Allan's report, as will be shown later.

The Pedigree

Evidently I-2 was a carrier, since she produced a son who had peroneal atrophy. It is assumed that either the father of I-2 had the trait, or that her mother was also a carrier, but no information could be obtained for previous generations. It is also probable that in generations I or II there were other sibs, who married and produced offspring, because a young man is known to IV-2 who is affected and is said to be a distant relative of the family. He is not shown here because no definite information was secured regarding his ancestors.

No data were available regarding the age at onset or condition at death of II-2. It was established that he was rather severely affected. He had only one child, a daughter (III-2), who was a carrier. She married twice, the first time to III-3. From this marriage three chil-



SEX-LINKED PERONEAL ATROPHY

Figure 10

Only males have been affected in alternate generations with transmission through females who themselves are normal. Complete disability due to muscle atrophy occurs later in this family than in some others reported elsewhere.

dren were born, a daughter (IV-7), an affected son (IV-9), and a normal son (IV-11).

IV-7 was apparently not a carrier. Her only son (V-12) was normal, and her two daughters (V-10 and V-11) married and have children, none of whom are affected. The exact number and sex of these children was not ascertained, since they reside in another state, their present address being unknown to the individuals who supplied the information shown in this pedigree. IV-11 had four sons and one daughter, all normal. These four sons and the daughter are all married and have children (not shown in this pedigree). None of them is affected.

IV-9 was badly handicapped before the age of twenty-one, at which time he began to use crutches in order to get about more easily. He could walk without crutches, even when he was sixty years old, but with great difficulty. He died at seventy, a helpless cripple. Several years before his death, he went to the field where he laid his crutches aside and hoed cotton. Apparently he could maintain his balance with the hoe, while using it. None of his living relatives know at what age he first became afflicted.

This man married twice. His first marriage produced two daughters (V-13 and V-18) and a son (V-15). The son was normal, as was to be expected, and produced two normal sons (VI-9 and VI-11), and a daughter (VI-8). Both of the daughters of IV-9 by his first wife were carriers. One of them (V-13) had three sons, one of whom (VI-2) was affected. This man, now thirty-two years of age, is able to walk without the use of crutches.

The other carrier daughter (V-18) is the mother of the two brothers to whom

previous reference has been made. She has four daughters, three of whom are married, one having three sons, and another a daughter. These sons (VII-3, VII-4, and VII-5) are apparently normal, but are as yet too young for definite diagnosis. Two of the three sons of V-18 are affected. VI-20 is 25 years old. He has had four treatments at a hospital for crippled adults. One of these treatments involved surgery of the lower legs and ankles. He has never had to use crutches. The other brother, V-21, is 21 years of age. He is not quite so severely affected as his brother.

The second marriage of IV-9 produced two sons and a daughter, all normal. The two sons are married and each has one child, both normal. The daughter married, but died without issue.

To the second marriage of III-2 three sons were born, two of whom were affected. IV-4 was past fifty when he died. He walked with the aid of two canes. He had two daughters, neither of whom married. IV-2 is still living and is past his seventieth birthday. He also walks with the aid of two canes, although with difficulty. The normal brother, IV-5, did not marry.

IV-2 has three daughters and a son. The three daughters are married and have children. One of these daughters, V-5, has one son two years old, too young for diagnosis. The number and sex of the children of V-1 and V-7 was not ascertained, but none is believed to be affected. Thus it is impossible to state definitely whether any of these three daughters are carriers.

From the foregoing discussion of this pedigree, it will be noted that the age at which this trait becomes evident is about the fifteenth year. This agrees with Allan's findings. But the age at which the individual becomes more or less helpless seems to be later than is the case of the affected persons in Allan's sex-linked pedigree. IV-2 is past seventy and still able to walk with canes. VI-2 is thirty-two and VI-20 is twenty-five, yet neither requires even a cane when walking.

The observed ratio of the affected and normal males in this pedigree fits the expected ratio for a sex-linked recessive. In generation IV there were five sons, three of whom had the trait. Of the individuals shown in generation VI, only the sons of V-1, V-5, V-7, V-13, and V-18 might be expected to be affected. Three of these females have a total of seven sons, three of whom show the trait. Thus, from a total of the twelve observed males in generations IV and VI who might be expected to have peroneal atrophy, six actually have it. In a sex-linked recessive trait (ignoring any "carriers" who produced no affected offspring), this is the exact expected ratio.

Summary

1. This trait affects males only. It is transmitted by an affected man through some of his daughters to about half of their sons. It is apparently due to a sex-linked recessive gene.

2. Sex-linked peroneal atrophy is characterized by the inability to support weight on the heels, a gradual atrophy of the calf of the leg, severe pain after prolonged use of the feet, and a marked reduction of efficiency in the use of the hands and fingers.

3. The trait first becomes evident at about the fifteenth year and gradually grows worse. The age of complete disability seems to vary with individuals. Complete disability seems to occur late in life in this pedigree, although Allan reports a pedigree in which disability occurs much earlier.

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INHERITANCE OF RAGGED WING IN THE FOWL

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BIRDS with defective flight feathers of the type here described as "ragged wing" were at about the same time brought to the attention of workers at the New York and the Kansas Agricultural Experiment Stations by breeders of White Leghorns in New York and Illinois, respectively.

Description

Birds affected with the ragged-wing mutation may show any grade of abnormality between wide extremes. In the most severely affected birds, all the remiges, both primaries and secondaries, are missing (Figure 11); at the other extreme, these wing feathers are all present, but somewhat shorter in length (Figure 12*B*) than is normal (Figure 12*A*). Birds of this latter class are sometimes difficult to classify with accuracy, and it is quite probable that cases occur wherein the shortening of the feathers is so slight that it is not recognized. Birds with all the remiges missing are not so common as those in which some or all of these feathers are present.

In moulting birds the number of primaries and secondaries is usually the same in each wing, but in fowls showing the ragged-wing mutation, there are occasional departures from the bilateral symmetry characterizing normal moulting fowls. This is illustrated, as is the variation in the character, by the following protocols of some affected females that were examined in detail when nine months of age.

G52. Left wing has short slender broken quills of what appear to be three inner primaries, and two or three broken shafts that apparently represent secondaries. Right wing has no primaries or secondaries.

G42. Left wing has three slender short primaries next to the axial; no secondaries. Right wing: same as left, but has three slender secondaries.

G59. Left wing has two short feathers, possibly primaries, but no larger than a covert; no secondaries. Right wing: three or four short and slender primaries; no secondaries.

G45. Both wings have the five inner primaries present, but only about five inches long, and correspondingly slender; no secondaries.

G46. Left wing seems to have 11 primaries, the right one 10. All are shorter than normal and more slender, as are the secondaries.

Classification

Ragged wing is not recognizable in the day-old chick or even in older chicks with fully developed juvenile plumage. The character is first identified in the adult remiges which begin to appear at six to twelve weeks, depending upon the rate of feathering. The adult remiges appear in a regular succession and are not well grown until the bird is about five months of age. The age at which the ragged-wing condition is recognizable depends upon the degree of its expression and the progress of the moult of the juvenile remiges. Extremely defective flights are recognizable in the early stages of the moult while slightly abnormal individuals will not be detected until the adult remiges are fully grown. This is shown by the records for 268 offspring from ragged-wing parents at Cornell in 1942 that were classified at about twelve weeks of age, and again at about 30 weeks of age. (Table I.)

These data show that birds with signs of the character at twelve weeks are likely to show it at maturity, but that the reciprocal is less consistently true: out of 76 with clearly ragged wings at 30

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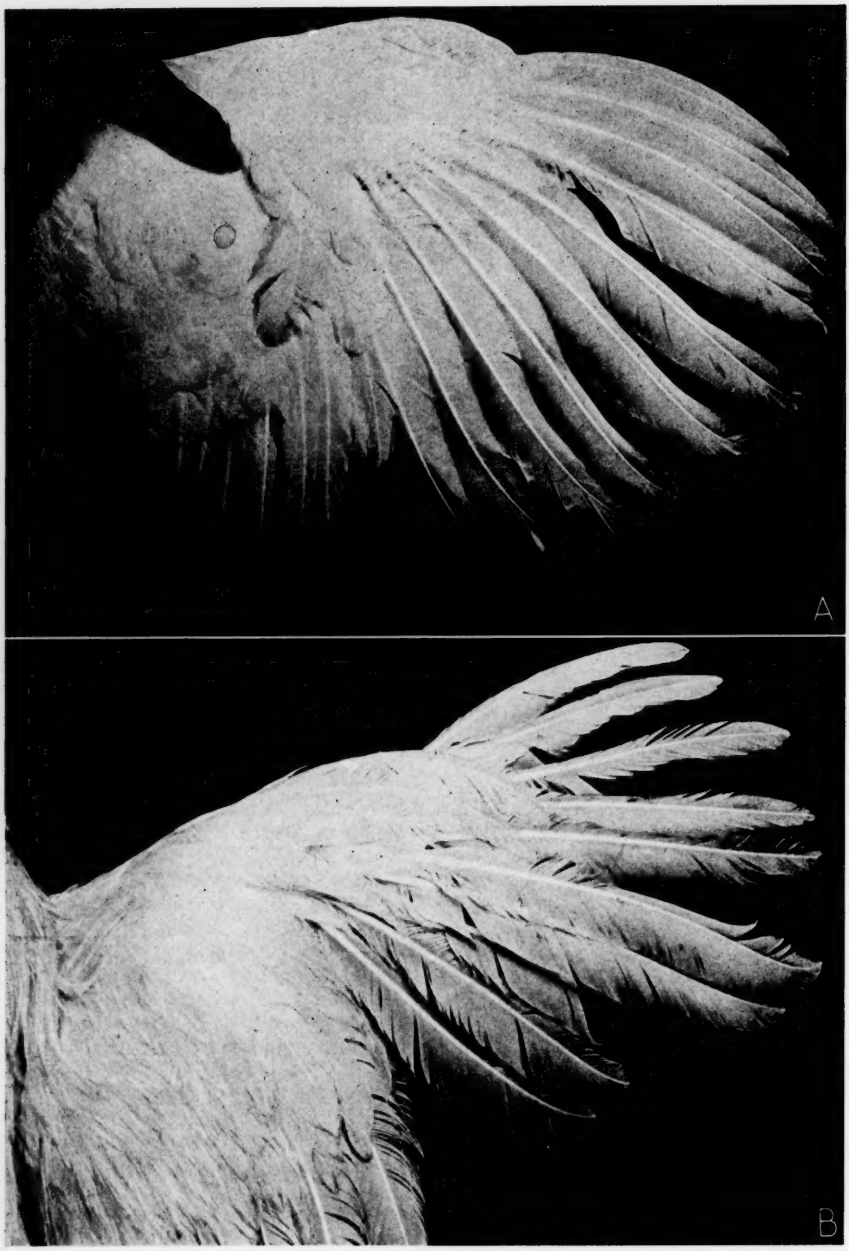
†Contribution No. 152 from the Department of Poultry Husbandry, Kansas State College.



NORMAL AND "SHORT WING"

Figure 12

A—A normal Leghorn wing with uniform secondaries and ten primaries showing a gradual gradation in length. *B*—The "short-wing" form of the character. The wing has ten primaries, which is the normal number, but these are all unduly short. The eighth primary (from the outer border of the wing) is broken.

weeks, only 16, or 21 per cent, had ragged wings or short flights at the earlier age. Similarly, among 62 showing at maturity the short flights that are the less extreme manifestation of the mutation, only eleven per cent were recognizable at twelve weeks of age.

The tail feathers are apparently normal in all birds with ragged wings, regardless of the degree of abnormality in the remiges. Even in females with no flight feathers whatever, the rectrices are normal in number and in length.

Genetics

Numerous matings were made independently at Cornell University and Kansas State College for the study of the mode of inheritance of ragged wing. The results at the two stations, as given below, are in close agreement, even though the classification of the segregates was made by different observers. Since there appeared to be no difference in the manifestation of ragged wings in the two sexes, the males and females have been combined in the tabulated results.

	Offspring	
	Normal	*Ragged-wing*
Ragged-wing × ragged-wing (Kansas)	127	129
Ragged-wing × ragged-wing (New York)	176	174
Ragged-wing ♀ ♀ × normal ♂ (Kansas)	50	0
Ragged-wing ♀ ♀ × normal ♂ (New York)	24	0
Normal ♀ ♀ × ragged-wing ♂ (Kansas)	69	3
Normal ♀ ♀ × ragged-wing ♂ (New York)	41	0
F_2 generation (Kansas)	113	1
Back-cross to ragged-wing (Kansas)	285	88

The reciprocal matings between ragged-winged individuals and unrelated normal stock show clearly that the character is recessive and not sex-linked. The three ragged-wing birds appearing in one Kansas F_1 generation mating probably were the result of some of the supposedly homozygous normal females being heterozygous for the factor. This seems quite possible in view of the widespread distribution of this gene which is shown later. It is also evident that, if a single pair of genes is responsible for the ragged-wing condition, there must be modifying genes which prevent full expression of the character. The existence of such modifiers is indicated by shortages of ragged wings in the various matings.

In every type of mating at either station, with the exception of the F_2 generation at Kansas and the three birds mentioned in the previous paragraph, the proportion of birds with ragged wings fits closely that expected if a single recessive gene were responsible for the character and if half the birds homozygous for the causative gene showed it. While this is most readily noticed in the matings of ragged-wing birds *inter se*, where the ratios are 1:1 instead of 1:0, it is also evident in the backcross to ragged wing. There the observed ratio was 285 normal: 88 ragged, whereas that expected on the basis just given is 280:93. In the F_2 generation the character was evidently suppressed in most birds for the observed ratio of 113:1 deviates considerably from the 100:14 expected if half the homozygotes were to show it, and still more from the usual 3:1 ratio.

Altogether these studies suggest that ragged wing and its less extreme variation, short wing, are caused by a recessive and autosomal mutation in one pair of genes, but that in the strains studied, presumably because of modifying factors, its effects are not recognizable in about half of the birds homozygous for the mutated gene.

Modifying Genes

The great variability of this character suggests that a number of modifying genes affect its expression. The matings at Cornell University were arranged to provide information on this point. Each of the two males used in 1942 was mated with a group of 12 females that included some with missing remiges (ragged), some with all remiges present but shortened (short), and two that were presumed to be homozygous for the mutation though apparently normal in every

RAGGED WINGS
Figure 11

A—The ragged wing of a White Leghorn male. None of the primary feathers is of normal length and most are missing. The secondaries are irregular in length. *B*—Under side of a ragged wing showing new primaries growing in. Several of them are all the same size, which shows that they have not been produced in succession from the inner primary to the outer one as in normal fowls.

respect. This assumption was based on the fact that in every case both parents of these four normal birds had had ragged wings, and siblings of all four were similarly affected. The manifestation of the character in the offspring of these matings is shown in Table II.

When the progeny of both males are considered together the proportions showing ragged wings or normal ones (birds with short wings omitted) were as follows:

	Ragged-wing per cent	Normal-wing per cent
From ragged-wing dams	39	39
From short-wing dams	24	53
From normal dams	10	62

It is clear from these data, and from those in Table II, that manifestation of the mutation is best in the progeny from ragged-wing dams, and least in the progeny of normal dams. In other words, the proportion affected in the offspring, and the grade of the character manifested by them, varies somewhat according to the phenotype of the dam. This is consistent with the interpretation that in birds homozygous for the mutation, modifying genes affecting the dam tend to affect similarly her offspring. It is to be noted from Table II that the proportion of short wings is virtually the same whether ragged- or short-winged dams were used, indicating that "short" is only a modified expression of ragged-wing.

Table I. Identification of ragged wing at different ages.

Classification at 12 weeks		Classification at 20 weeks		
		Ragged	Short remiges	Normal
	Number	Number	Number	Number
Ragged wing	12	11	-	1
Short remiges	18	5	7	6
Normal	238	60	55	123
Totals	268	76	62	130

Table II. Phenotypes of progeny in relation to that of dam.

Sire	Classification of dam	Progeny	Phenotype of progeny		
			Ragged	Short	Normal
		Number	Percent	Percent	Percent
J4004	Ragged	46	41	24	35
"	Short	70	20	26	54
"	Normal	30	13	33	53
J4007	Ragged	37	37	21	42
"	Short	46	30	17	53
"	Normal	9	0	11	89

Distribution of the Mutation

During the course of this study evidence was accumulated that the gene for ragged wing is fairly wide-spread in the poultry population of this country. The original ragged-winged birds at Cornell University came from a New York breeder of White Leghorns. Cornell University workers later found the character in two other White Leghorn and Rhode Island Red flocks of that state. The original Kansas ragged-winged birds came from a White Leghorn flock in Illinois, and workers there later received a bird of the same type from a New Jersey White Leghorn flock. During the period of study a single ragged-winged bird appeared in a Kansas State College flock of Rhode Island Reds that had been closely observed for a number of years. Breeding tests showed that the same mutation was responsible for the condition in the five flocks coming to the attention of the New York workers and the same was true of the three coming to the attention of Kansas workers.

Finally, matings between the original Kansas and the New York ragged-wing stocks also demonstrated that the same gene was involved in the two sources. When a Cornell ragged-wing male sent to Kansas was there mated with ragged-wing females of the Kansas stock, the 55 progeny included 21, or 38 per cent, with ragged wings. This could not have happened unless the same genes were responsible for the condition in both stocks.

Summary

A new mutation affecting the flight feathers of the wings is described. In the most extreme form it eliminates all the remiges from the adult plumage. In its least evident form, these flight feathers are all present but shorter than normal. In most cases, some of the remiges are present, others missing. The rectrices are unaffected.

The character is not evident at hatching and even at twelve weeks of age is manifested by only a small proportion of the birds that show it in the adult plumage.

Independent genetic analyses at Kansas State College and at Cornell University agreed in finding that the ragged-wing condition is inherited as an autosomal recessive character, but that only about half of the recessive homozygotes show it, the rest being indistinguishable from normal birds. The evidence suggests that, while a single pair of recessive genes with major effects is responsible, there are also modifying genes that prevent full expression of the character.

Breeding tests showed that the same mutation was present in five flocks in New York State and three in Kansas. It was found in both White Leghorns and Rhode Island Reds.

The Dight Institute of the University of Minnesota

Announcement of the organization and aims of the Dight Institute of the University of Minnesota is made in Bulletin No. 1 of that Institute, just published.

The Institute derives its support from the income of a bequest made by the late Dr. Charles S. Dight of Minneapolis. Its purpose is to support the study of genetics as it applies to man. Approximately $4500.00 per year will be available for this purpose. There is to be an annual general lecture on some aspect of eugenics. (The first of these was given on May 10, 1942, by Dr. Philip Levine, whose subject was the "Sereological Differentiation of Human Blood: Theoretical and Practical Considerations.") The Institute is cooperating with the School of Medicine and Dentistry of the University of Minnesota. Plans have been perfected to receive and file information on inherited characteristics in man. It is hoped that out of this catalogue of inherited traits, linkages can be established which will increase the predictive value of the analysis of individual human family pedigrees. It is hoped also that through a study of the various phenotypic expressions of human genes, pathological and otherwise, a wider appreciation of the importance of human genetics can be fostered and its clinical value greatly increased. There is also to be a consultative clinic for advice and information on human heredity.

The bulletin concludes with a biographical sketch of Dr. Charles S. Dight. He was born in 1856 in Pennsylvania and received his M.D. degree from the University of Michigan in 1879. Throughout his life he had had an evangelical zeal for reform and humanitarian movements. An earlier interest in such social amelioratives as technocracy, share-the-wealth, agricultural reforms, back to the land propaganda, temperance, and socialism, forced his conviction that through eugenics the most rapid progress in human betterment was possible. Between 1921 and 1935 some three hundred letters written by Dight on various aspects of eugenics were published by the Minneapolis newspapers. In 1928 he organized and was elected president of a Minnesota Eugenics Society. He was convinced that sterilization was the quick and effective panacea for a number of social ills and his persistence was primarily responsible for the passage of a Sterilization Law in Minnesota in 1925. This resulted in only a small number of sterilizations annually, and Dight constituted himself a one-man lobby which, through press and radio, fought for a strengthening of this law.

The variety of boards and experts proposed in his various bills to speed up sterilization in Minnesota suggest that quantity of operations rather than quality of the determination of the need for them was the primary objective.

In spite of his long and highly vocal preoccupation with eugenics, it appears that the residents of Minneapolis will remember him more for his "tree house" than as a champion of race improvement. This was an ingeniously constructed abode designed for a single occupant. It became the subject of numerous newspaper stories and it seems to have been, on the whole, rather an unsatisfactory way of living. The chief moral this seems to point in connection with the founding of the Dight Institute is that in a culture which is inclined to minimize the biological basis for human differences in physique and ability, only the rampant individualist is likely to become as vocally interested in eugenics as was Dr. Dight.

Under the direction of Dr. Clarence P. Oliver the funds made available by Dr. Dight should aid materially in advancing the aims of the founder. Here is another center which will encourage a realistic and sound approach to the understanding and utilization of human hereditary differences to foster the betterment of mankind.—R. C.

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